

**APPARATUS AND METHOD FOR MONITORING OF**  
**AN AUTOMATIC DEICING CONTROLLER**

5

**BACKGROUND OF THE INVENTION**

**1. Field of the invention.**

The present invention relates to deicing equipment, and, more particularly, to automatic controls for deicing equipment used to melt and remove snow and ice from pavement, roofs,  
10 gutters, downspouts and the like.

**2. Description of the related art.**

Electric and hydronic heaters are commonly used to melt ice and snow. Applications include pavement and similar structures, but also include roofs, downspouts and gutters. Pavement applications include sidewalks, driveways, stairs, drive through window areas,  
15 building portals, loading docks, bridge decks, parking garages and off ramps, etc.

Typically, automatic controls are utilized to sense ambient temperature and moisture to control ice removal heating equipment. Heater elements may include hydronic tubing installed under or proximate to areas in which the removal of ice or snow is desirable. Hydronic systems include an interface with a heating system that provides energy for the removal of ice and snow.  
20 Electrical heating cables may also be employed that consist of stranded copper wires separated by a semi-conductor polymer enclosed in one or more layers of organic insulating material, this type of electrical cable is often referred to as self-limiting or self-regulating heating cable. Additionally, an insulated resistant wire may be used, which maintains a relatively constant resistance as it dissipates heat. The insulation may consist of magnesium oxide or various  
25 polymeric materials.

The status of, and functioning of, the automatic control can be determined by way of a visual indicator on the control or an electrical interface to which an electrical device can be connected to analyze the functioning of the control. The visual indicator thereon may indicate the sensed temperature, the presence of electrical power and whether moisture is detected.

- 5     Additionally, the automatic control can be checked if the temperature and moisture are controlled to a point of causing the controller to energize the heating system to thereby verify operation of the control system.

- What is needed in the art is an automatic heater controller that can convey its status without the need for, and the cost of, a display or an electrical interface on the controller or the  
10     need to physically simulate an environment in which to turn on the heating system.

### **SUMMARY OF THE INVENTION**

The present invention provides an apparatus and monitoring method in which the heater control can be monitored.

- 15     The invention comprises common in one form thereof, an ice and snow melting heater control assembly including at least one sensor, at least one heater element and a controller communicatively coupled with the at least one sensor and the at least one heater element, the controller directing status information about at least one sensor to the at least one heater element.

- An advantage of the present invention is that a controller can be checked for operation  
20     without simulating an environment therefore.

Another advantage is that the heater controller of the present invention can provide status information to a technician.

Yet another advantage is that the control circuit can be manufactured without the need to include visual indicators or readouts on the control circuit itself.

Yet still another advantage is that the present invention allows the status of the automatic controller to be determined without the additional cost of any additional parts.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

5           The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is combination perspective view of an embodiment of a heater control of the  
10   present invention and a schematical form of typical external circuitry attached thereto;

Fig. 2 is a schematic diagram of a heater control of Fig. 1; and

Fig. 3 is a block diagram of a method used by the heater controller of Figs. 1 and 2.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention,  
15   in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

### **DETAILED DESCRIPTION OF THE INVENTION**

Referring now to the drawings, and more particularly to Fig. 1, there is shown one  
20   embodiment of a deicing control system 10 of the present invention. System 10 includes power system 12 and control system 14.

Power system 12 includes power conductors 16 and 18, control conductor 20, relay coil 22, relay contact 24 and heater system 26. Power conductors 16 and 18 are connected to electrical power such as a 120 volt circuit. Power conductors 16 and 18 also provide power to

control system 14. Control conductor 20 receives a signal from control system 14 that drives relay coil 22 causing a controllable connection of relay contact 24 thereby allowing power to flow from power conductor 16 through heater system 26 to power conductor 18. Heater system 26 can be the controlling pump of a hydronic heating system 26 or an electrical heating element  
5 26.

Now, additionally referring to Fig. 2, there is shown a control circuit 30, which is part of control system 14. Control system 14 also includes moisture detector 32 and temperature detector 34. Moisture detector 32 includes a moisture grid that is a spaced apart interdigitated set of conductors exposed on the top of control system 14. Moisture, in the form of water, ice, snow  
10 and/or sleet on the surface of moisture detector 32 is detected by a current flow between fingers of the interdigitated conductors.

Prior moisture detectors measured the conductivity between the interdigitated conductors using an uninterrupted supply of a DC voltage. This causes electrochemical problems including polarization and copper electroplating that reduces the life expectancy and reliability of the  
15 sensor. Polarization occurs when DC current flows through the grid when wet. The water from melted snow and ice becomes an electrolyte due to atmospheric contamination and the ions therefrom are positioned, due to the constant electro-potential on the interdigitated fingers. However, the circuit and method employed by the present invention reduces this problem to a negligible proportion by employing an active sensing technique that reduces the current through  
20 the moisture detection grid by more than an order of magnitude. Further, the circuit detects moisture on the sensing grid in the form of ice, in any form, without the need for heating the sensor to turn the ice into water. An advantage of this approach is that heat is not dissipated in the moisture sensor at a higher rate than that utilized in the pavement, or other application areas, where the heating element is distributing the heat. The advantage of this is that the moisture on

the moisture detector will dissipate at the same rate as the moisture on the ground or other area under the control of control system 14. The selection of the power density that is applied to the moisture sensor to melt the snow and ice on the conductive grid is such that it operates to allow the snow and ice to be removed at approximately the same rate as that on the ground. This

5 advantageously permits a shorter hold-on time of the heating system thereby saving energy. The hold-on time ensures complete melting of the moisture and the evaporation of any standing melt water. Power to the moisture sensor is turned off at temperatures above 38° F. At lower temperatures excitation of moisture detector 32 is continuous until precipitation is detected. Thereafter, moisture detector 32 is electrically activated at predetermined intervals, such as every

10 six minutes, for a few seconds to check for the presence of moisture. If moisture had been previously detected, then the detection of a lack of moisture marks the beginning of the heater hold-on time interval. This modulating of the DC voltage on moisture detector 32 advantageously reduces the average current flowing through moisture detector 32 thereby prolonging its life.

15 Additionally, another technique in detecting moisture involves the measurement of AC conductivity of the moisture-sensing grid of moisture detector 32. Low frequency AC excitation reduces the electrochemical deterioration of the surface of the moisture sensing grid when it is exposed to precipitation in any form, since the average current is zero. Further, the measurement of the AC capacitance of the moisture-sensing grid of moisture detector 32 may be used to detect

20 moisture.

Control circuit 30 incorporates a negative temperature coefficient precision thermistor 34 to convert the ambient temperature into a voltage value using half of a DC excited Wheatstone bridge. The other half of the bridge is supplied by a successive approximation routine that utilizes an analog-to-digital converter in microcontroller 36. Since both halves of the

Wheatstone bridge are excited by supply voltage  $V^+$ , the encoded temperature value is essentially independent of variations in  $V^+$ .

Control circuit 30 includes microcontroller 36, relay 38, field effect transistor (FET) 40, heater elements 42, FET 44, FET 46, capacitor 48 and resistor 50. Controller 36 is

5 interconnected with temperature detector 34, FETs 40, 44 and 46. FET 40 controls the driving power to relay 38, thereby providing an electrical connection between power line 16 and control line 20. This places microcontroller 36 in control of the power supplied to heating element 26. FET 44 is connected to resistive elements 42 that are proximate to and/or integrated with moisture detector 32. Resistors 42 provide heat to moisture detector 32 when energized by FET  
10 44. FET 46 functions as an operational amplifier having a feedback capacitor 48 and a feedback resistor 50. Feedback capacitor 48 serves to integrate current conducted from moisture detector 32. Feedback resistor 50 provides a leak off of the integrated value otherwise integrated by FET 46, capacitor 48 and current from moisture detective 32.

Conductors 52, 54, 56, 58 and 60 electrically interconnect microcontroller 36 with  
15 elements of control circuit 30. Conductor 52 connects controller 36 with FET 40 thereby allowing controller 36 to turn power on to heater element 26 in a controllable manner.

Conductor 54 is interconnected with controller 36 and FET 44 thereby controlling power to heating elements 42 that heat moisture detector 32. The control of heat to moisture detector 32 is selected such that the power density applied thereto matches the power density in the deicing  
20 area. Microcontroller 36 advantageously controls the power supplied to heater elements 42, in a programmed manner, to substantially match the heat density applied to moisture detector 32 to that supplied to the deicing area by way of heating element 26. Conductor 56 provides a voltage level from thermistor 34 that corresponds with the external temperature. The voltage level is utilized by controller 36 to determine the ambient temperature and decide when to activate FETs

40, 44 and 46. For example, if the temperature detected from thermistor 34 is above 38°, FETs 40, 44 and 46 will not be activated. When the temperature detected is below 38° F moisture detector 32, by way of conductors 58 and 60, is activated to determine if any moisture is present on moisture detector 32. If moisture is detected on moisture detector 32, then conductor 52 is energized thereby causing FET 40 to be conductive causing the contact in relay 38 to close, thereby providing power to relay coil 20, causing relay contact 24 to close, thereby directing electrical power to heating element 26. FET 44 is modulated according to a prescribed power density to approximate the power density of heater element 26. Once moisture is detected from moisture detector 32, conductor 60 is de-energized for a predetermined amount of time. After the predetermined amount of time conductor 60 is re-energized to again detect the presence or absence of moisture on moisture detector 32. Conductor line 58 serves as a sensor input to microcontroller 36 and conductor 60 supplies power to moisture detector 32. Microcontroller 36 is a microprocessor driven controller and in the preferred embodiment a microchip 12C672 8-bit Harvard Architecture device is utilized. Microcontroller 36 advantageously has analog input and digital input/output ports, which are correspondingly interconnected to conductors 52, 54, 56, 58 and 60.

Now, additionally referring to Fig. 3, there is shown a method 100 that is executed by microcontroller 36. Method 100 is initiated at step 102, upon power on of control system 14 or upon a manual initiation, for example, by the pressing of a button not shown. Upon initiation, method 100 proceeds to step 104 in which controller 36 obtains the operational status of control system 14. Operational status includes a test of moisture detector 32, a reading of temperature reported by detector 34 and the status of power applied to FETS 40, 44 and 46. Status information thus obtained at step 104 is then available for transmittal at step 106.

At step 106, status information about control system 14 is directed to heater element 26 by way of relay 38 and relay elements 22 and 24. The information is conveyed by a predetermined pulsing of relay 38 causing the current flowing through heating element 26 to be turned on and off in a predetermined pattern. The pulsing of the current through the heater  
5 element 26 can be detected by an operator having placed a clamp-on amp meter around conductor 28 to thereby detect the pattern being pulsed from control system 14. The information passed to heater element 26 includes the current temperature detected by temperature detector 34 and whether or not moisture detector 32 is detecting any moisture. Additionally, status regarding microcontroller 36 and the status of relay 38 upon turn on may be directed to heater element 26.

10 Method 100 proceeds to step 108 wherein controller 36 reads a memory contained within microcontroller 36 that contains historical operating information. The historical operating information may include performance in a previous time period such as the last time controller 36 energized heater element 26 and the duration thereof.

At step 110, microcontroller 36 sends the historical data to heater element 26 again by a  
15 predetermined pulsing pattern of power under the control of FET 40, relay 38 and relay elements 22 and 24. The information sent to heater element 26 is thereby interpreted by an operator observing a voltmeter detecting the application of voltage to heater element 26 or by way of an amp meter detecting the current through conductor 28. Alternatively, if relay elements 22 and 24 include a light circuit, the operator can detect the pulse pattern by observing the light on the relay  
20 or listen to the relay closures. Advantageously, the present invention conveys information regarding control system 14 to a user by way of a pulse pattern to the heating element, thereby allowing control system 14 to provide operating information without the need of applying a controlled temperature and moisture environment to temperature detector 34 and moisture detector 32 to thereby test the operation of control system 14.



The information provided from control system 14 to heater element 26 and conductor 28 may be in the form of pulsing steps, which include varying the time duration of pulses or the frequency of pulses in the pattern. The pattern of pulses is completed in a relatively short period of time upon turn power-up of control system 14. The relatively short period of time may be less than one minute in duration and more specifically less than 30 seconds. Additionally, the pulse pattern may be delayed for a short period of time allowing an operator to move from a power on switch to the amp meter to thereby detect the information. The delay in operation may be a predetermined time such as 2 minutes.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.